ARCH 497A BIM STUDIO
FINAL PROJECT DESIGN

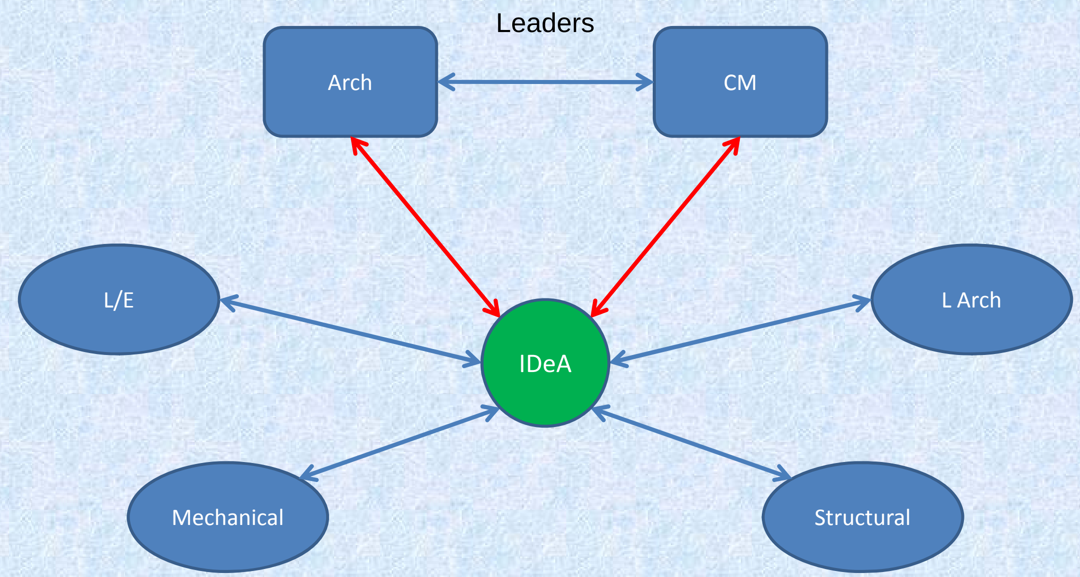
IDeA

Integrated Design and Architecture

Integrated Project Delivery

Goals

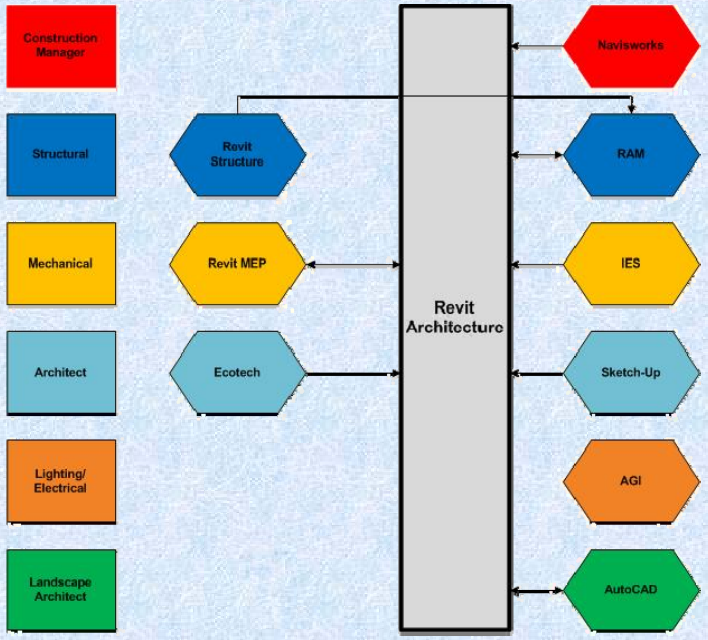
1. Involve all disciplines at the beginning of design
2. Focus on better design from all perspectives rather than optimization of one particular discipline
3. Spend less time in later stages of design



Building Information Modeling

Goals

1. Take advantage of the ability to share information across disciplines
2. Develop a complete 3D model
3. Utilize clash detection to find conflicts between systems immediately
4. Obtain quicker material takeoffs for more accurate estimates
5. Use compatibility features with other design programs for more accurate analysis



Design Goals

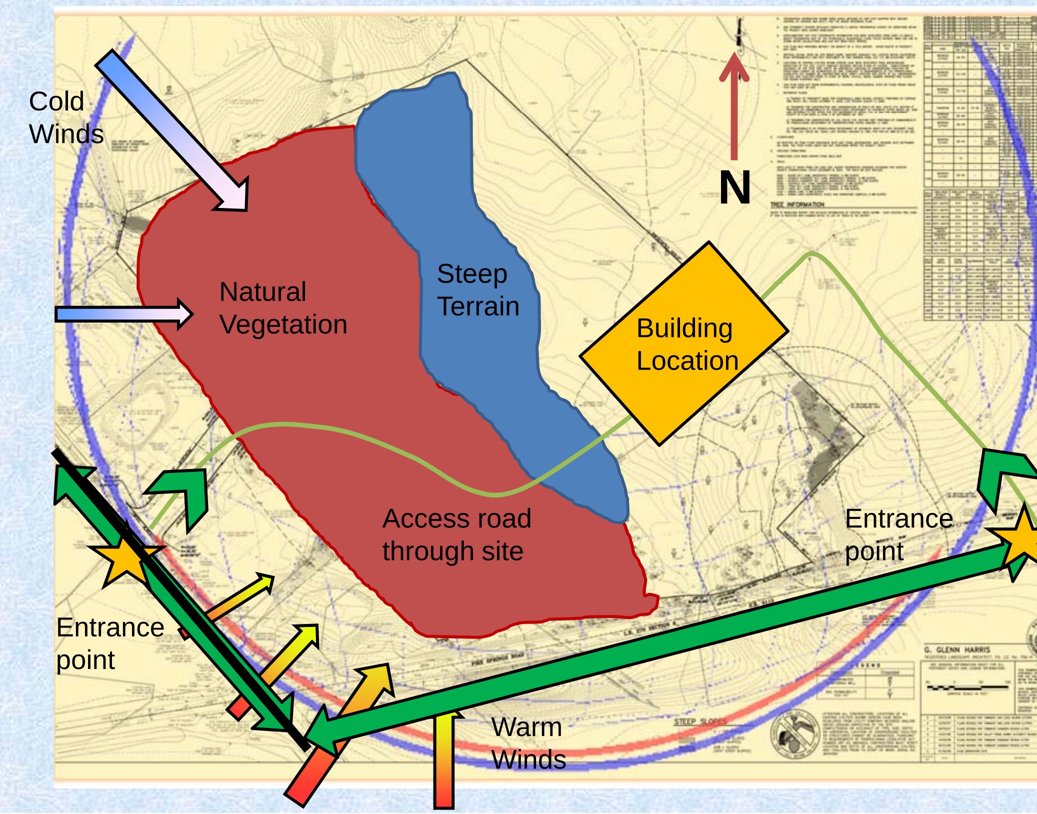
BIM → ← IPD

1. Enhanced Learning Environment
   •Student Interaction
2. Sustainability
   •Day lighting
   •Rainwater collection
   •Minimal site disturbance
3. Stay close to original program
   •Square footage
   •Connectivity

Site Layout and Selection

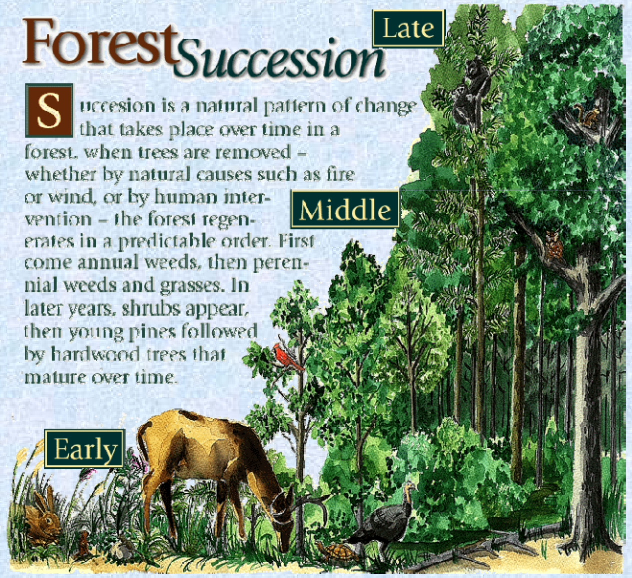
Criteria:

1. Site Disturbance
2. Wind
3. Solar
4. Construction
5. Traffic
6. Utilities



Overall Site Plan

Planting Zones

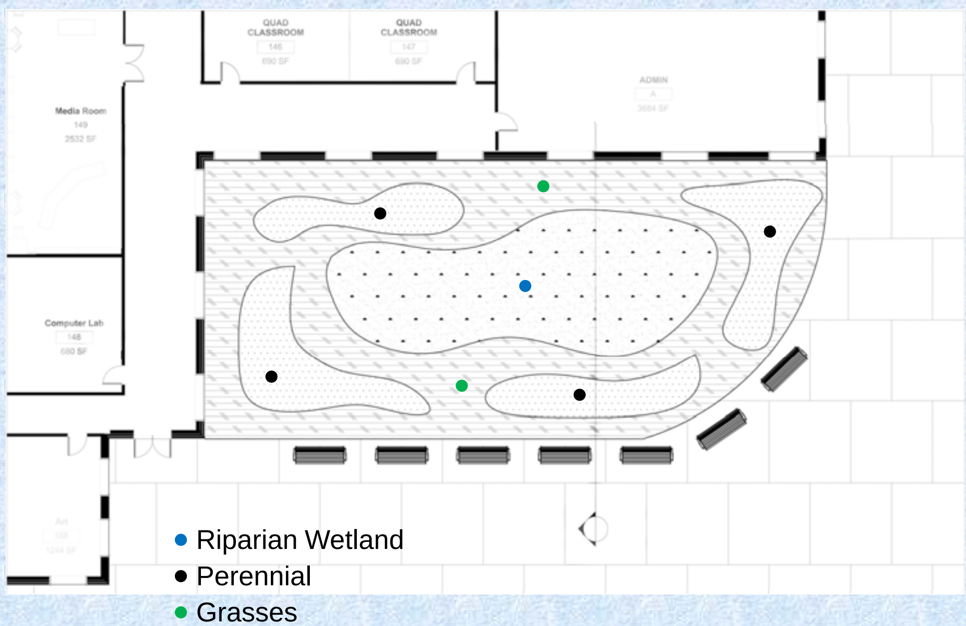


Early Successional
-Annuals, Perennials, Weeds, Grasses
Middle Succesional
-Shrubs, Young Pines
Late Succesional
-Hardwood Trees

Main Entrance

Entrance Planting Plan

Entrance Planting Design



Riparian Wetland/Grasses

- Big Bluestem
- Indian Grass
- Side Oats Gramma
- Switch Grass

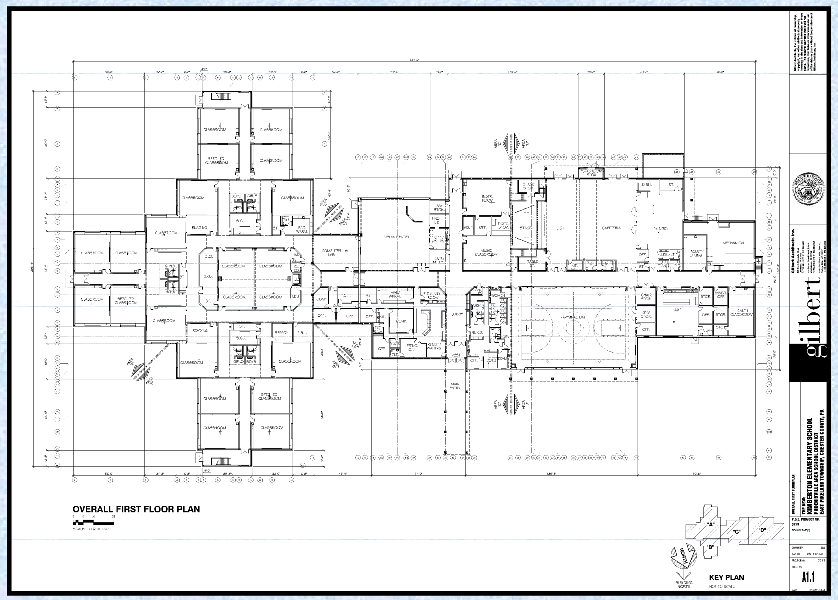
Forbs/Perennials

- Purple Coneflower
- Yarrow
- Wild Indigo
- Bush Clover
- Silver Rod

Planting DesignSection

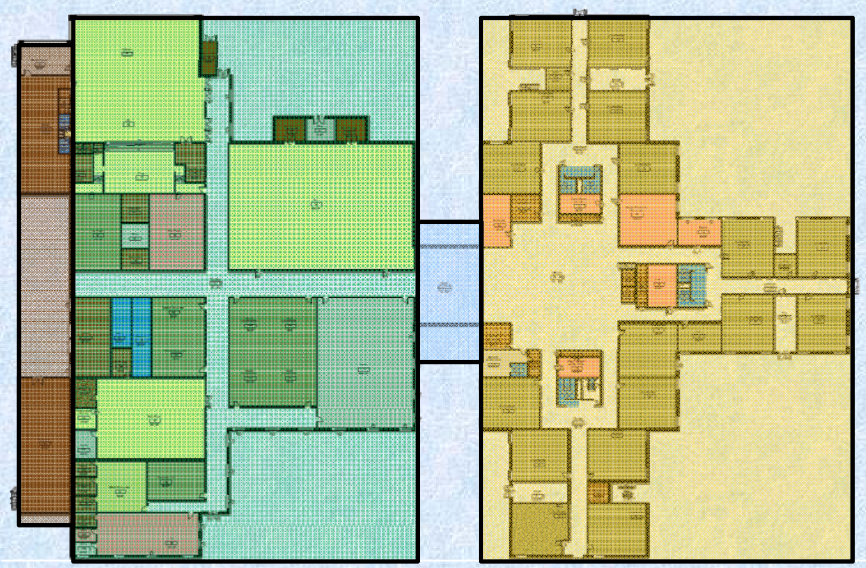
Low area in center of garden will hold stormwater runoff from the building roof and immediate ground plane. An overflow drain will be placed at the lowest point for large storm events so flooding doesn't occur. Overflow will be piped out to stormwater basin.

Prototype



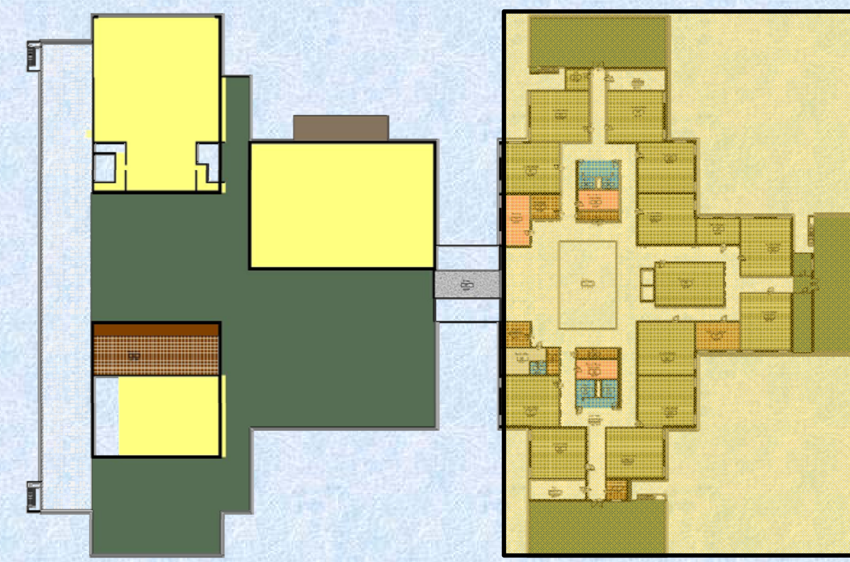
1st Floor Plan-New Design

Zoning

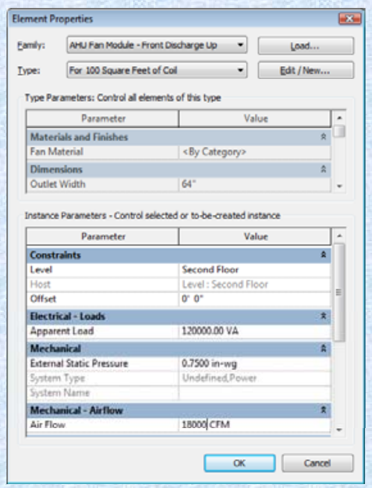


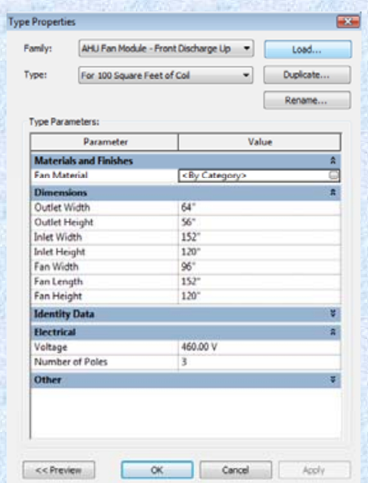
2nd Floor Plan-New Design

Zoning



Active chilled beam

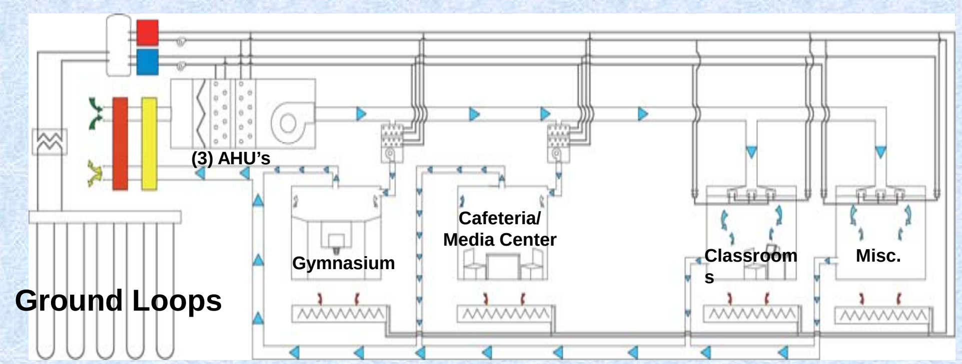




Radiant floor heating

Mechanical System Design

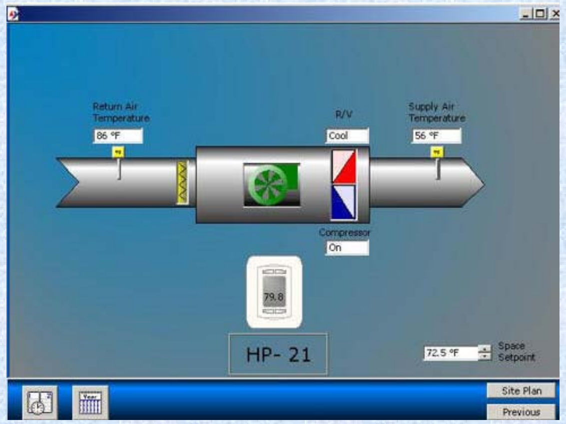
- Dedicated Outdoor Air System
- Chilled Beams and radiant floor heating for the majority of the building
- Three AHU's
  - 18000 CFM classrooms and misc.
  - 5000 CFM for gymnasium
  - 8000 CFM for cafeteria/media center
- Advanced heat recovery and dehumidification



Design Criteria

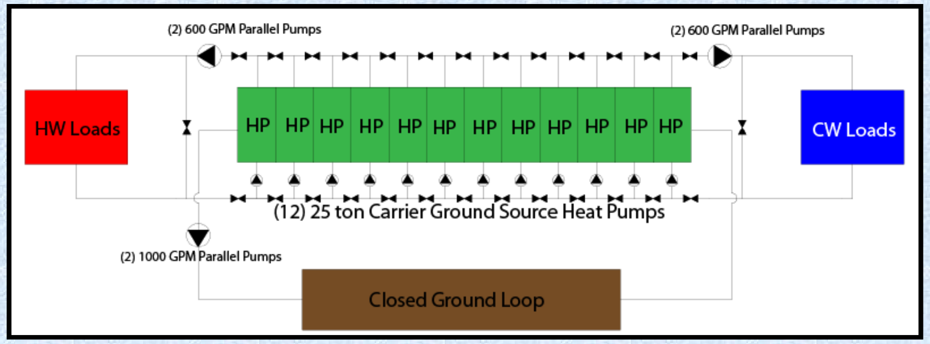
1. Healthy environment
2. Physical comfort
3. Energy efficiency
4. Cost
5. Space Requirement

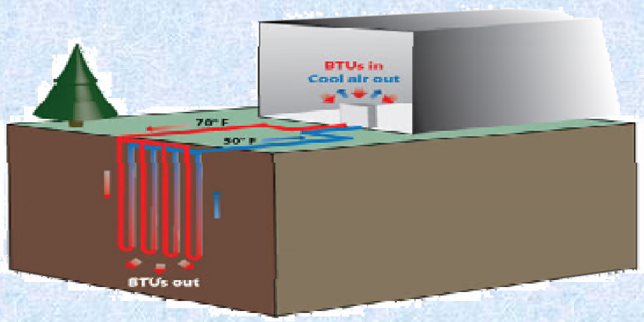
Mechanical System Design



Remote monitoring of mechanical system

- (12) 25 ton Ground Source Heat Pumps
- Set up like a modular boiler system for efficiency as well as thermal comfort
- Direct Digital Controls



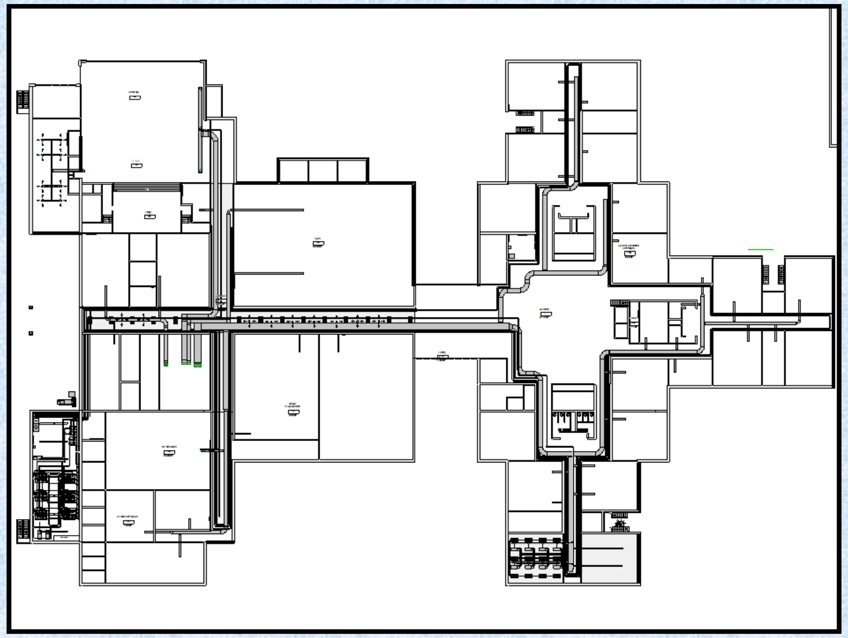


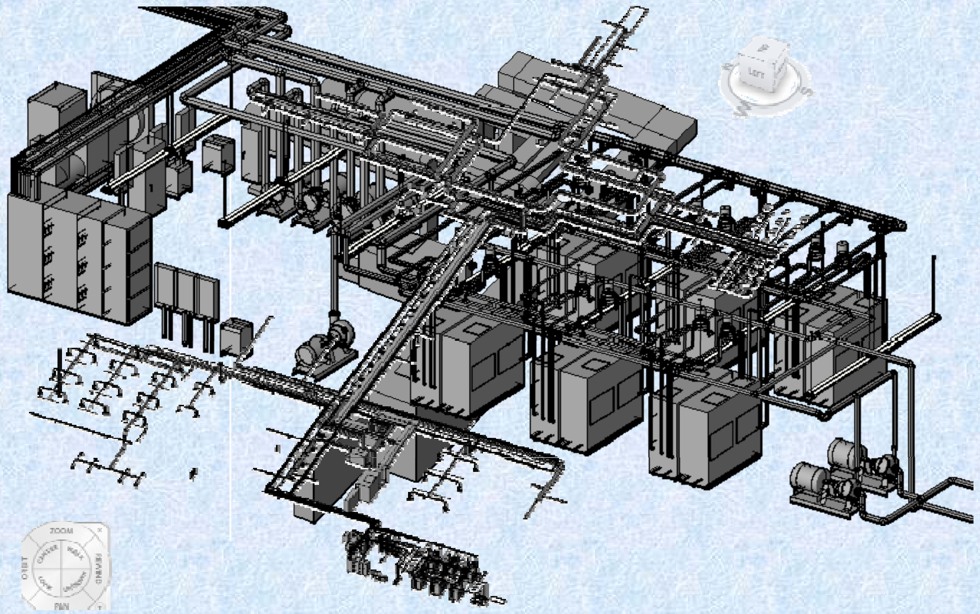
Closed group loop
(Geothermal)

Mechanical/Electrical System Layout

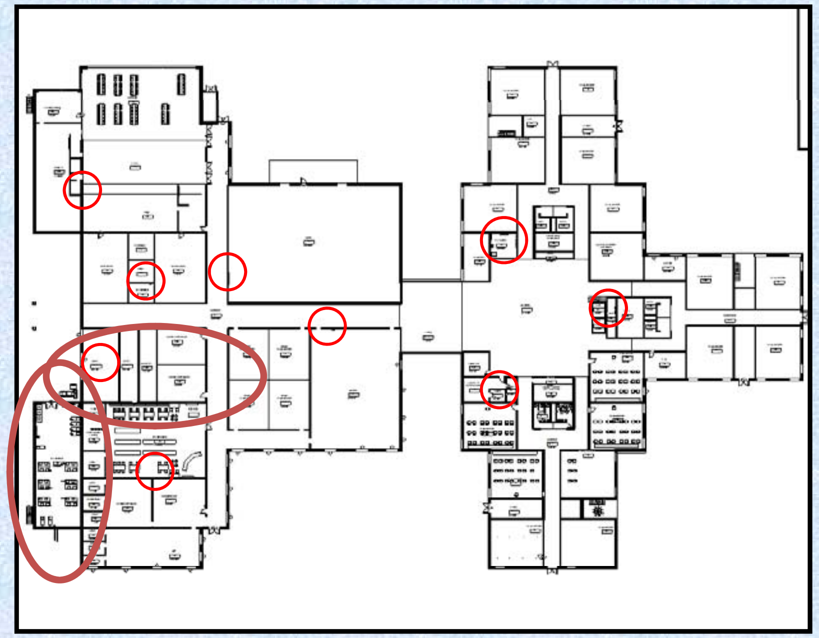
Main Mechanical/Electrical Room Layout

2nd Floor Mechanical/Electrical Distribution

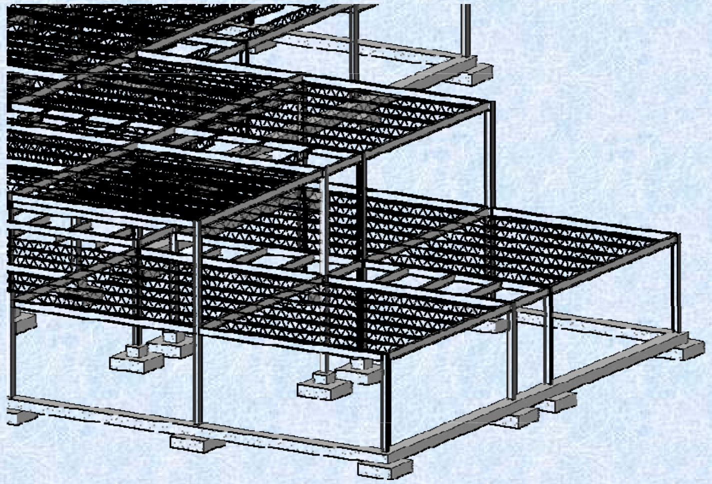




Panel board Layout



Revit Modeling



Structural System Design

Two wings of building act independently of one another

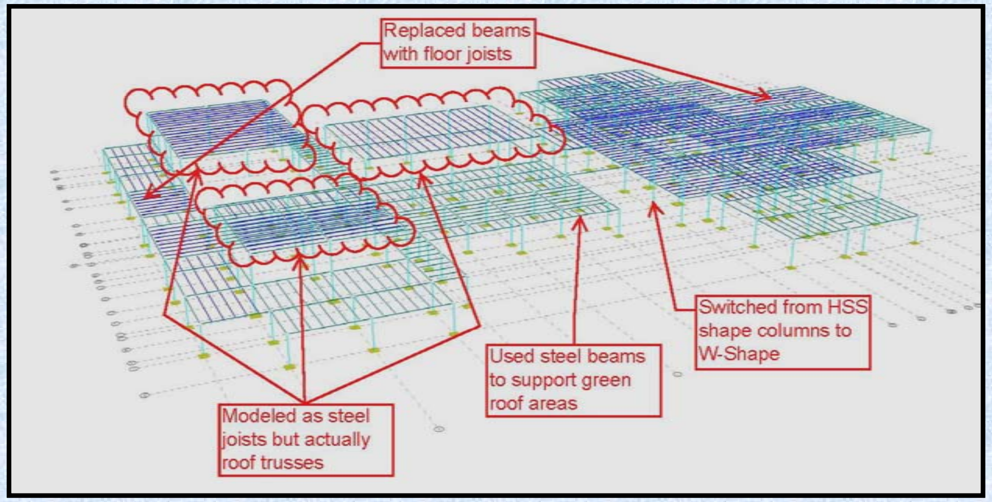
Gravity System
•Non-composite steel framing with spread footings
•14 different sizes of beams
•18 different sizes of joists
Lateral System
•8” thick concrete shear walls
Floor System
•4” concrete slab on grade
•4” thick second floor
 •1.5” steel decking
 •2.5” normal weight concrete

Design Criteria

1. Lifetime of structure
2. Flexibility
3. Aesthetics
4. Cost
5. Thermal Efficiency
6. Compatibility with other building systems

Structural System Design

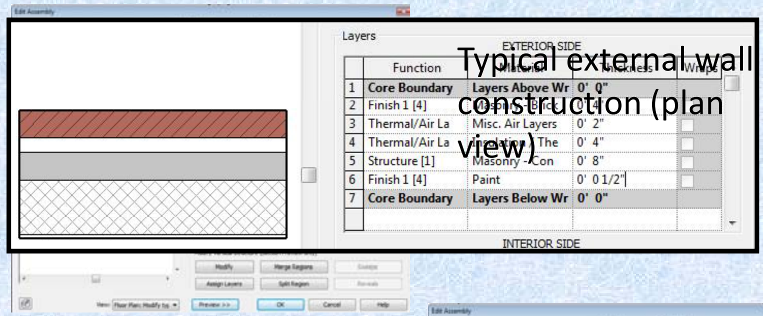
RAM Schematic



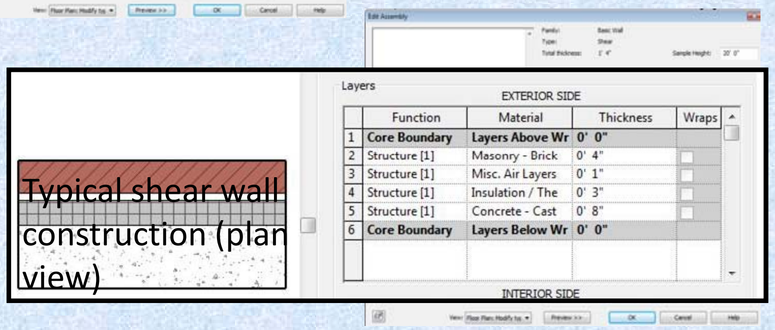
Key Adjustments

- Replaced beams on second floor with floor joists
- Switched columns from HSS to W-shape
- Shear walls take lateral load to foundation
- Green roof areas supported with steel beams

Wall Construction



Typical external wall construction (plan view)



Typical shear wall construction (plan view)

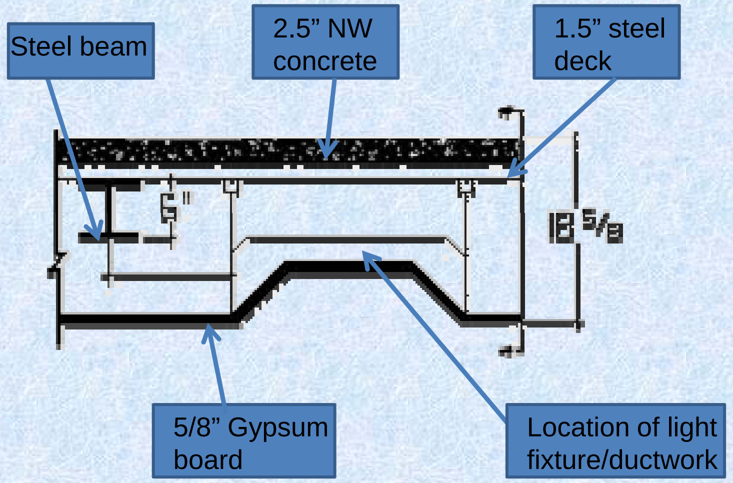
Code Requirements

Construction Type

Type 1A

Fire rating = 2 hr for floor assembly

Structural System Design



Restrained Assembly Rating
2 hr.
Unrestrained Assembly Rating
2 hr.
W6x15.5 minimum size

Assembly Details

Air Ducts

•Galvanized steel 22 gauge min.
•Total area of duct openings shall not exceed 288 sq. in per each 100 sq. ft of ceiling
•Duct opening shall not exceed 576 sq. in.
•Max opening size = 10 in

Damper

•Held open with fusible link

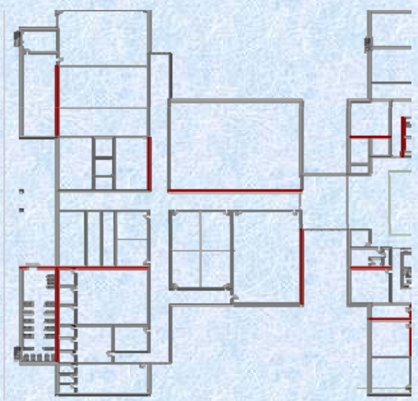
Fixtures

•Area shall not exceed 16 sq. ft per 100 sq. ft of ceiling

Floor assembly tested by Underwriters Laboratories Inc.

Structural System Design

Shear Wall Layout



1st Floor
Cafeteria/Gymnasium wing

Results

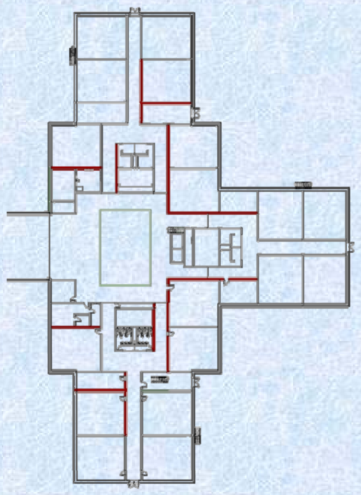
Placed open web steel joists in classroom areas
•Can result in cost savings over steel beams
•Live Load Deflections meet L/360 criteria
•Total Load Deflections meet L/240 criteria

Steel beams support green roof and corridors
•Necessary for extra load applied in these areas
•Beam camber was limited to 1.50”
•All beams meet deflection criteria stated above

Lateral load resisting system consists of shear walls
•For each wing of the building , approximately 180 linear feet of shear wall is necessary in each direction

Shear Wall Layout

1st Floor Classroom Wing



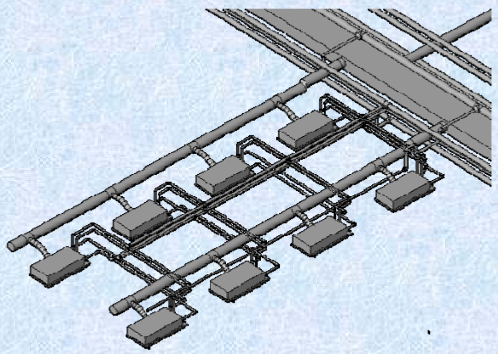
2nd Floor Classroom Wing

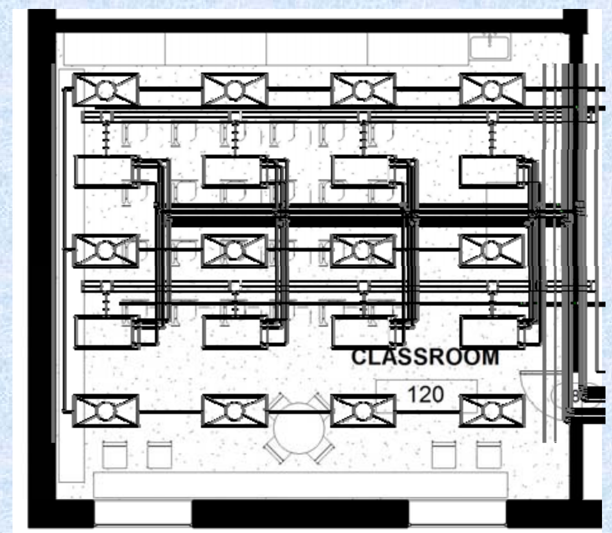
Structural System Design

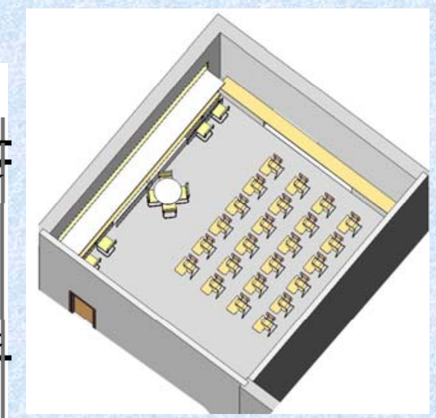
Revisit Design Criteria

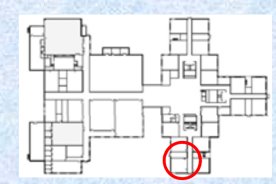
- ☑ Lifetime of structure
- ☑ Flexibility
- ☑ Aesthetics
- ☑ Cost
- ☑ Thermal Efficiency
- ☑ Compatibility with other building systems

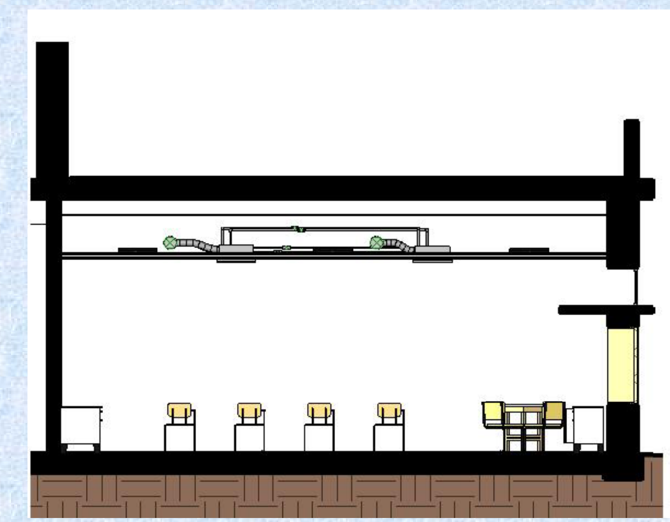
Focus Area - Classroom



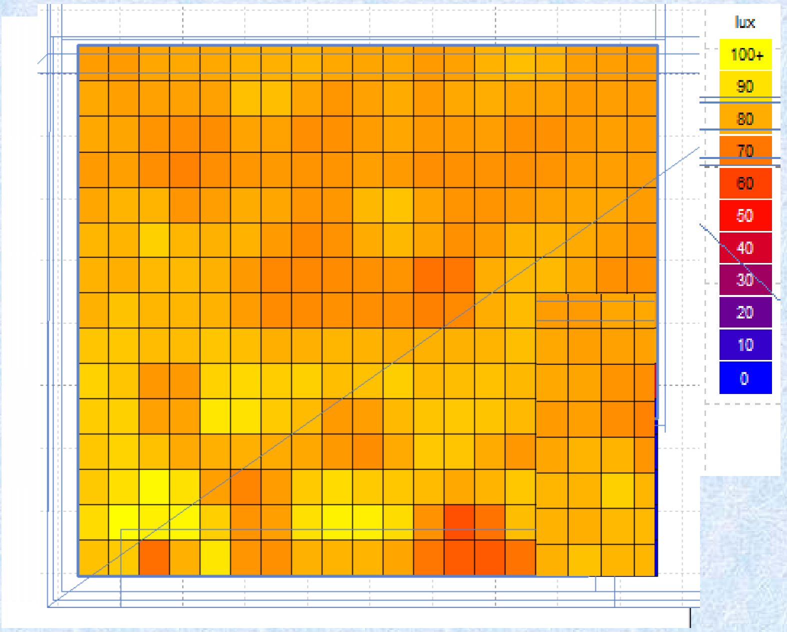


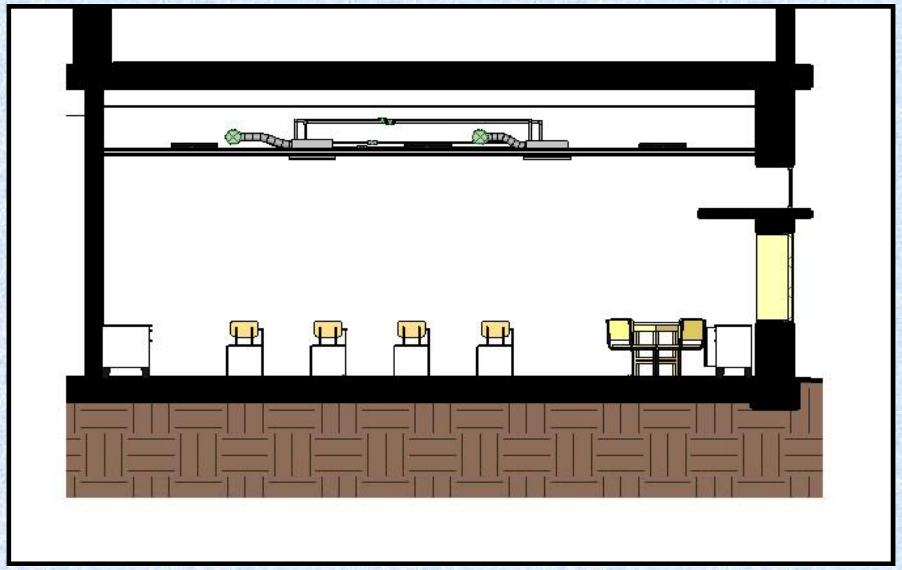




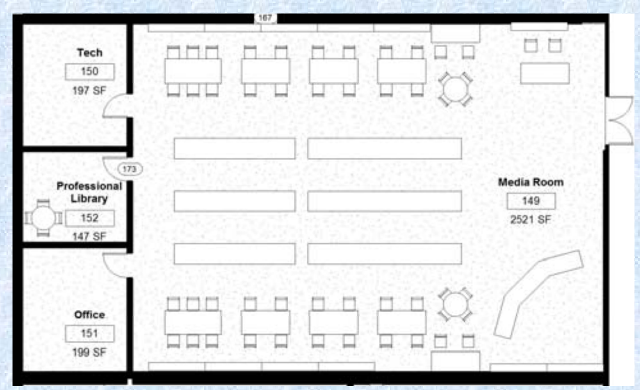


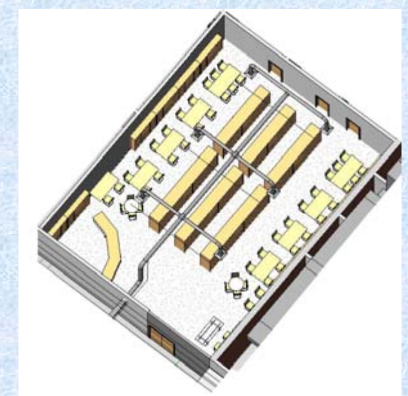
Classroom Day Lighting

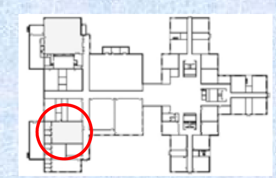


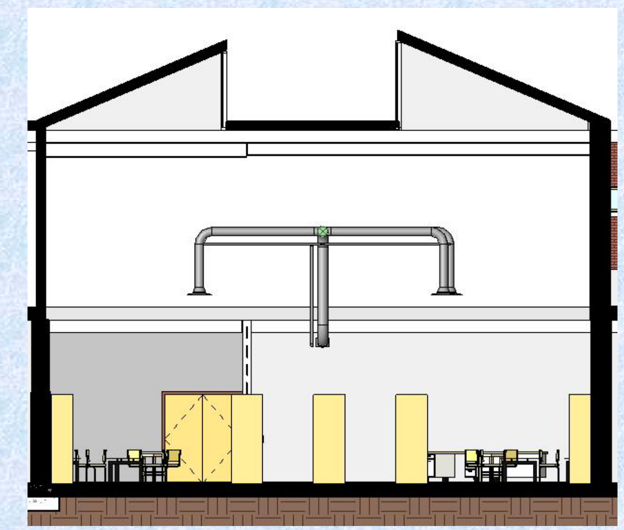


Focus Area – Media Center

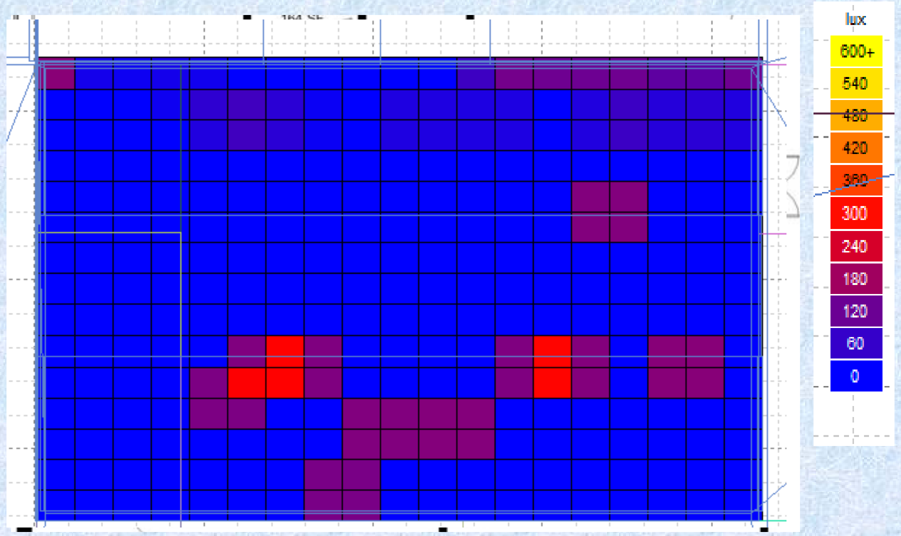




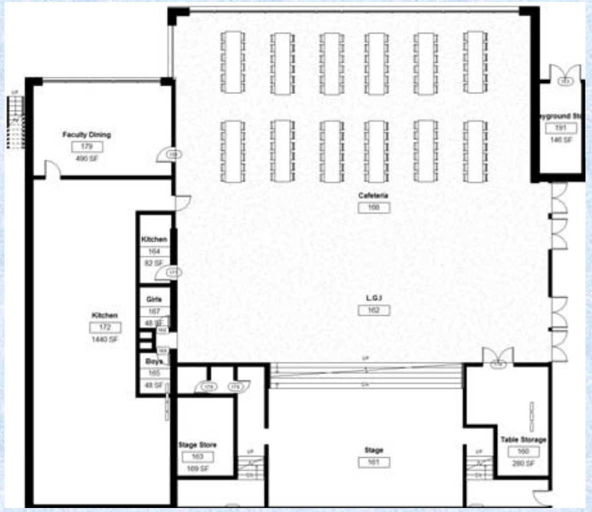


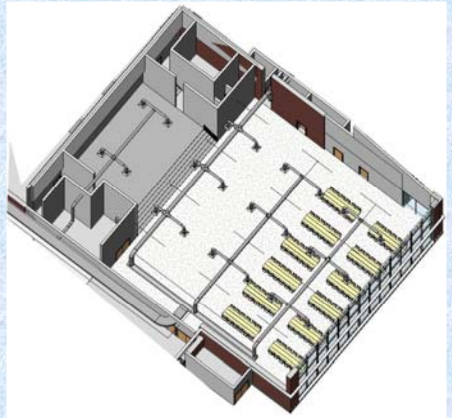


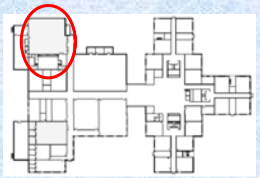
Media Center Day Lighting

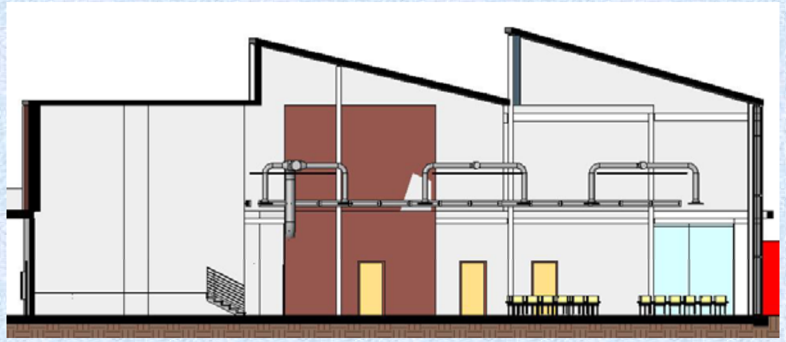


Focus Area - Cafeteria

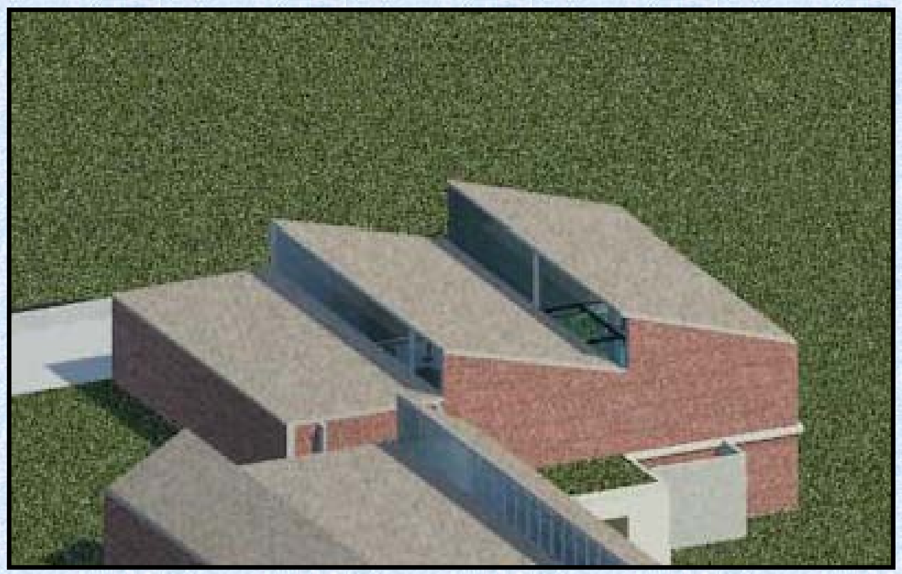


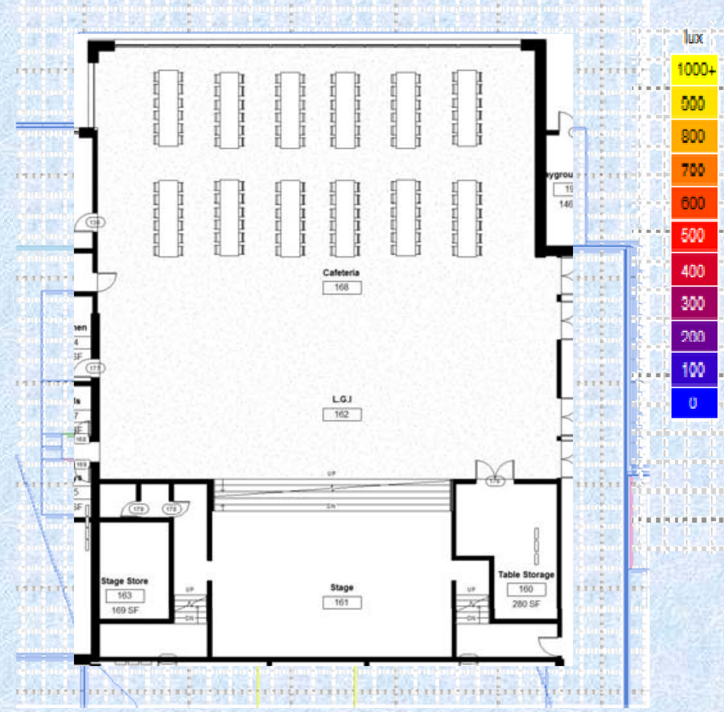


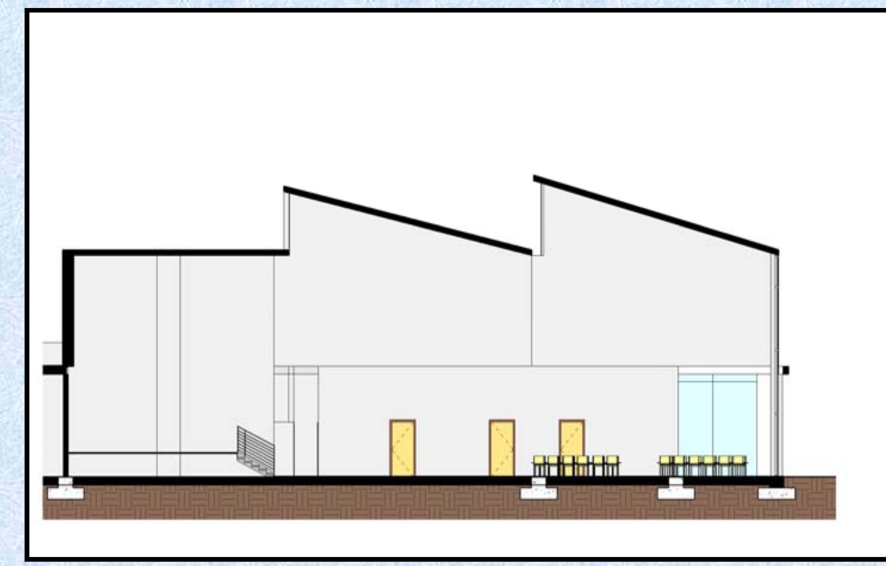




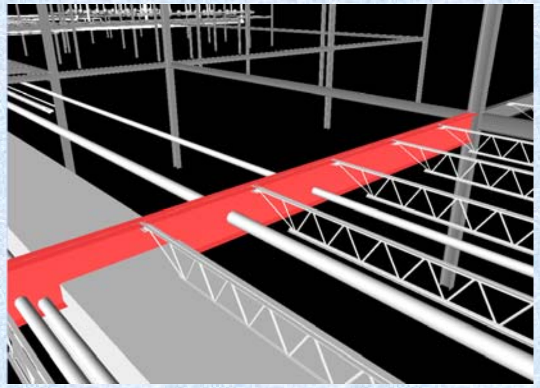
Cafeteria Day Lighting

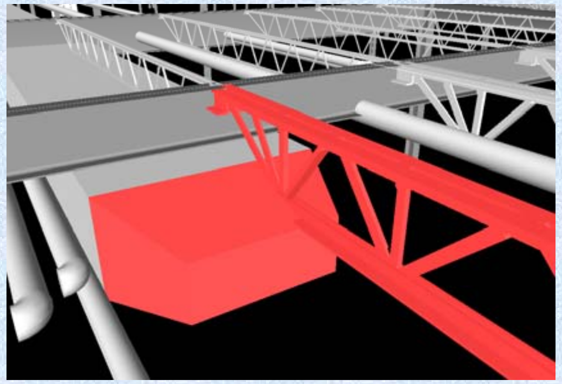


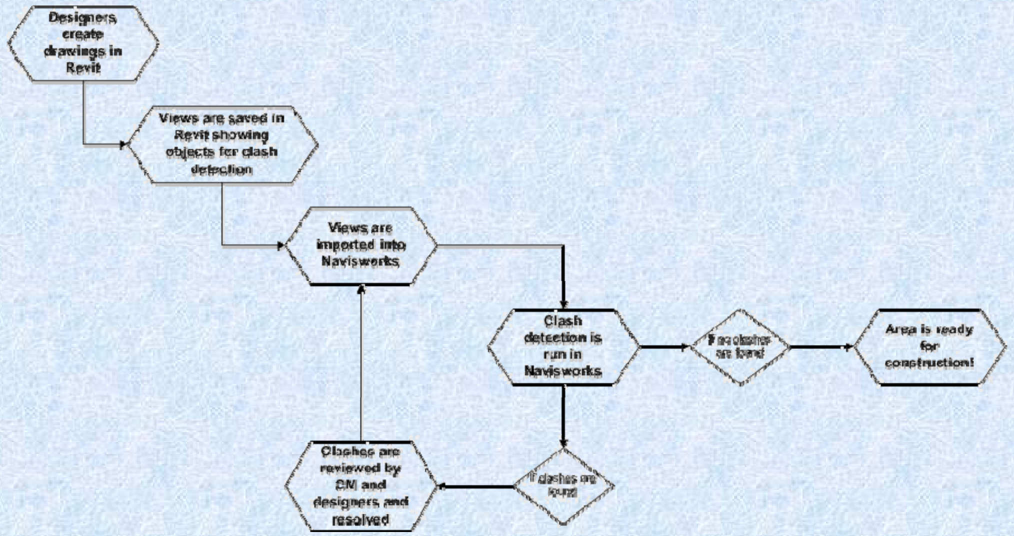




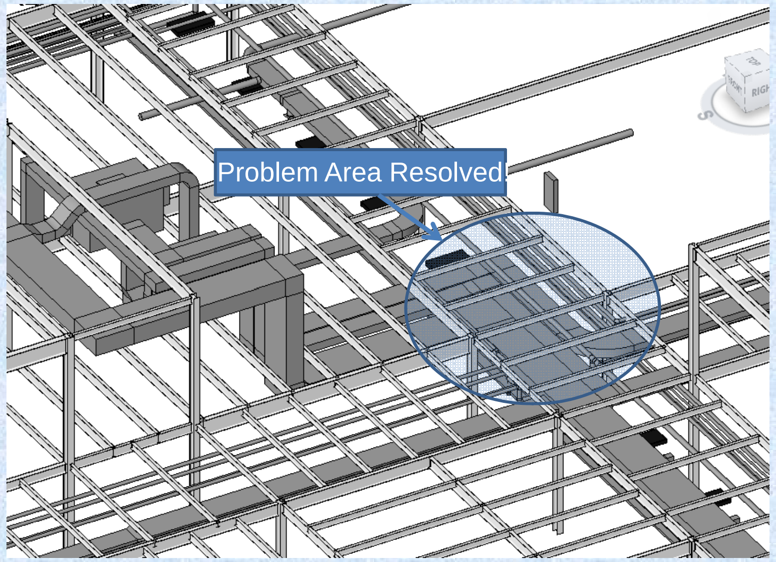
Clash Detection







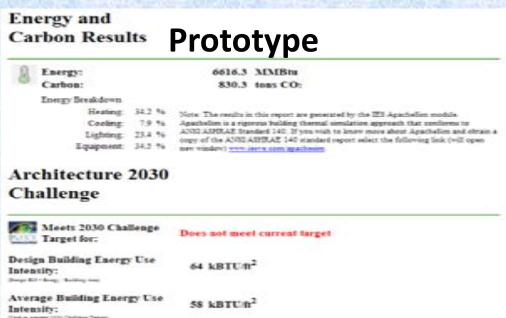
3rd Time Through – No Clashes Detected



Energy Analysis

Completed in Revit!!

Prototype



Energy and Carbon Results

Energy:	6616.3	MMBtu
Carbon:	830.3	tons CO₂

Energy Breakdown

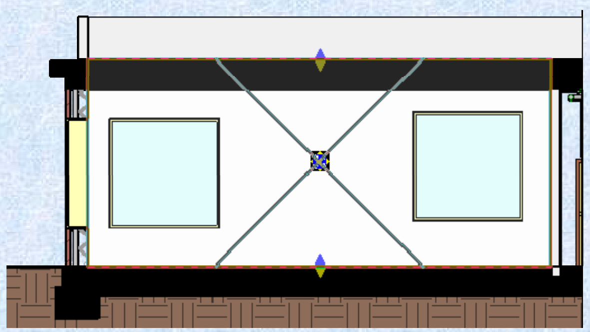
Heating	34.2 %
Cooling	7.9 %
Lighting	23.4 %
Equipment	34.5 %

Architecture 2030 Challenge

Meets 2030 Challenge Target for: Does not meet current target

Design Building Energy Use Intensity: 64 kBTU/ft²

Average Building Energy Use Intensity: 58 kBTU/ft²



VAV & Chilled Beams

INTEGRATED ENVIRONMENTAL SOLUTIONS

Energy and Carbon Results

Energy:	5876.2	MMBtu
Carbon:	685.6	tons CO₂

Energy Breakdown

Heating	42.8 %
Cooling	8.2 %
Lighting	27.0 %
Equipment	21.9 %

Architecture 2030 Challenge

Meets 2030 Challenge Target for: Does not meet current target

Design Building Energy Use Intensity: 55 kBTU/ft²

Average Building Energy Use Intensity: 63 kBTU/ft²

VAV

INTEGRATED ENVIRONMENTAL SOLUTIONS

Energy and Carbon Results

Energy:	6856.1	MMBtu
Carbon:	828.1	tons CO₂

Energy Breakdown

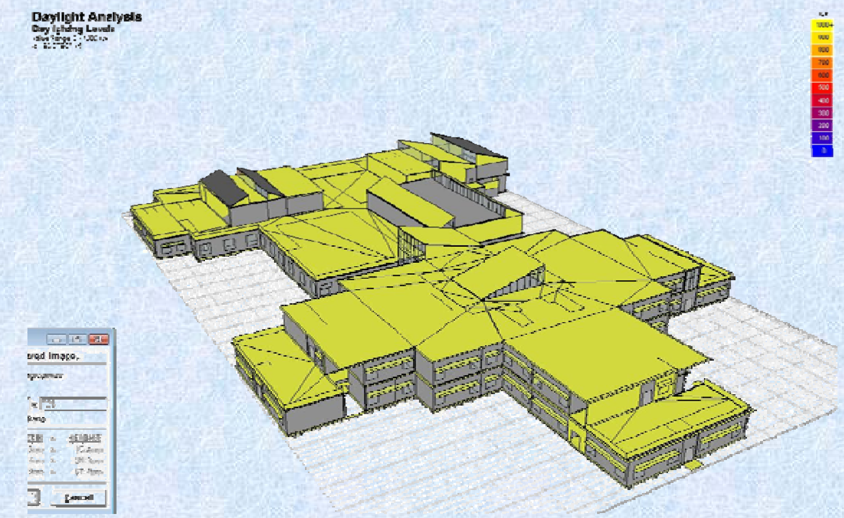
Heating	38.8 %
Cooling	8.3 %
Lighting	23.2 %
Equipment	29.7 %

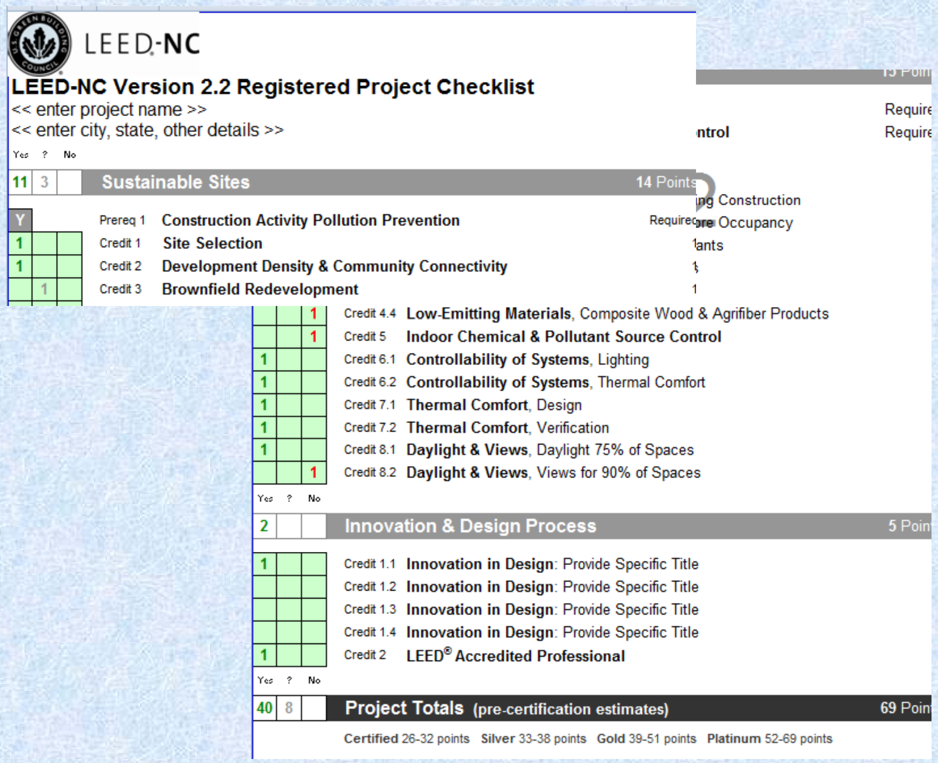
Architecture 2030 Challenge

Meets 2030 Challenge Target for: Does not meet current target

Design Building Energy Use Intensity: 65 kBTU/ft²

Average Building Energy Use Intensity: 60 kBTU/ft²





LEED-NC

LEED-NC Version 2.2 Registered Project Checklist

<< enter project name >>

<< enter city, state, other details >>

Yes	?	No				
11	3			**Sustainable Sites**		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**		Required
1			Credit 1	**Site Selection**		
1			Credit 2	**Development Density & Community Connectivity**		
	1		Credit 3	**Brownfield Redevelopment**		
		1	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products		
		1	Credit 5	**Indoor Chemical & Pollutant Source Control**		
1			Credit 6.1	**Controllability of Systems**, Lighting		
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort		
1			Credit 7.1	**Thermal Comfort**, Design		
1			Credit 7.2	**Thermal Comfort**, Verification		
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces		
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces		
Yes	?	No				
2				**Innovation & Design Process**		5 Points
1			Credit 1.1	**Innovation in Design**: Provide Specific Title		
			Credit 1.2	**Innovation in Design**: Provide Specific Title		
			Credit 1.3	**Innovation in Design**: Provide Specific Title		
			Credit 1.4	**Innovation in Design**: Provide Specific Title		
1			Credit 2	**LEED® Accredited Professional**		
Yes	?	No				
40	8			**Project Totals** (pre-certification estimates)		69 Points

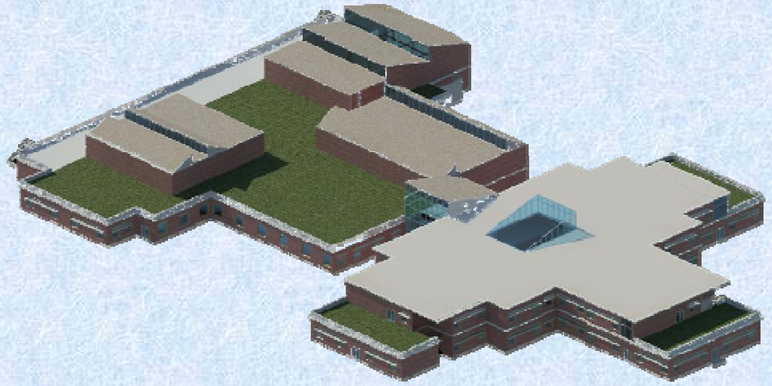
Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

LEED Checklist

- **Achieved a LEED Silver Rating with 37 Points**
  - Sustainable Site Design
  - Indoor Environmental Quality
  - Low Emitting Materials
  - Recycled Materials
  - Controllability of Systems

Category	Points
Sustainable Sites	11
Water Efficiency	3
Energy & Atmosphere	8
Materials and Resources	4
Indoor Environmental Quality	11
Innovation & Design	0
Total	**37**

Construction Cost Estimate



Structural Cost Comparison

Item	Current Cost*	Original Cost*	% Difference From Original
Concrete	$677,980	$665,339	1.90 %
Steel	$1,079,237	$1,486,726	-27.41%
CMU*	$894,185	$1,391,995	-35.76%
Total	$2,651,402	$3,544,060	-25.19%

*Cost adjusted for brick veneer replacement

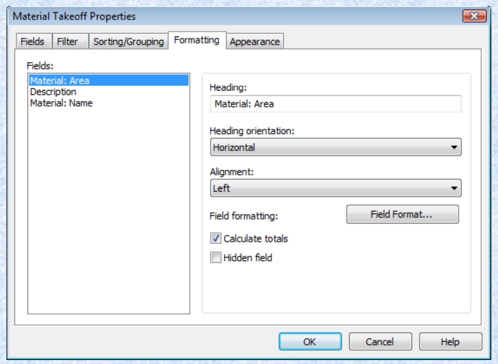
Observations

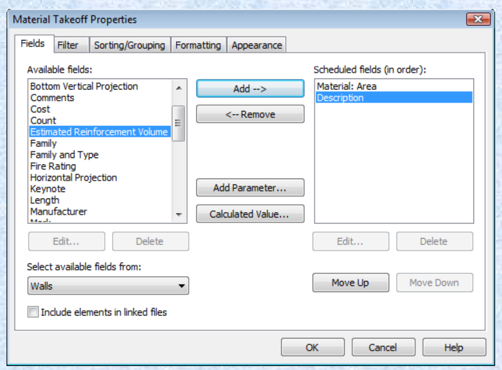
Joists saved about 25% on steel costs!

Corridor modification saved 35% on CMU costs

- Some of the savings may have come from shear wall savings
- Reduction of CMU due to brick veneer added (CMU removed)

Construction Cost Estimate





Total Construction Cost Comparison

Current Cost*	Original Cost*	% Difference
$22,275,500	$22,368,000	-0.41%

SF Construction Cost Comparison

Current	Original
$212.32	$217.21

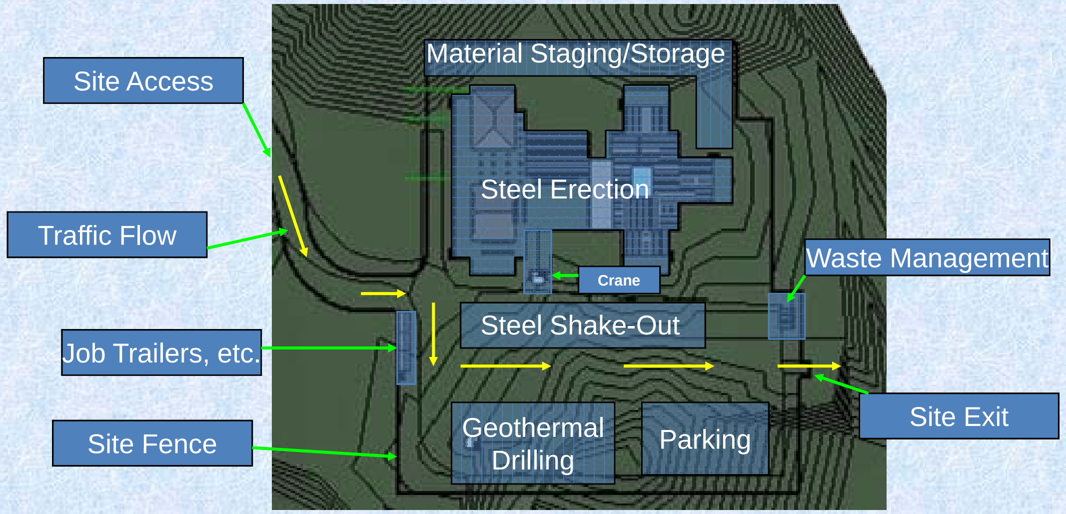
*Cost does not include design contingency, escalation contingency, insurance, O&P, or bonds

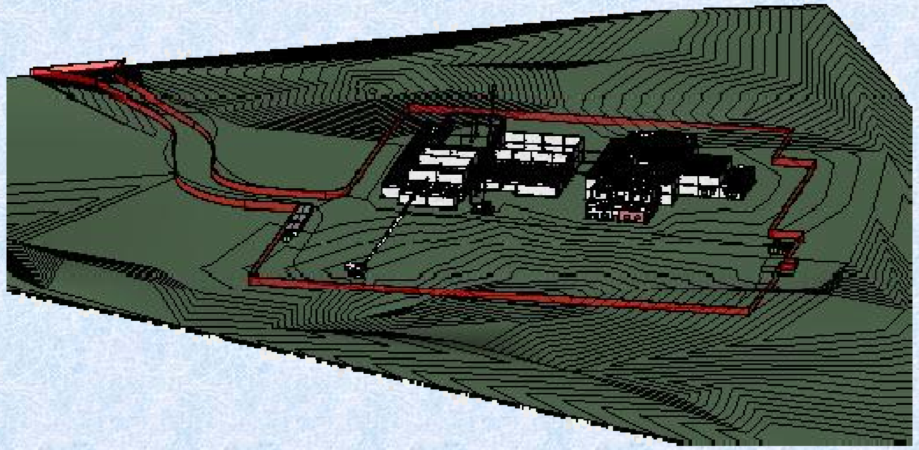
Significant Changes

- Masonry
- Metals
- Thermal and Moisture Protection
- Doors and Windows

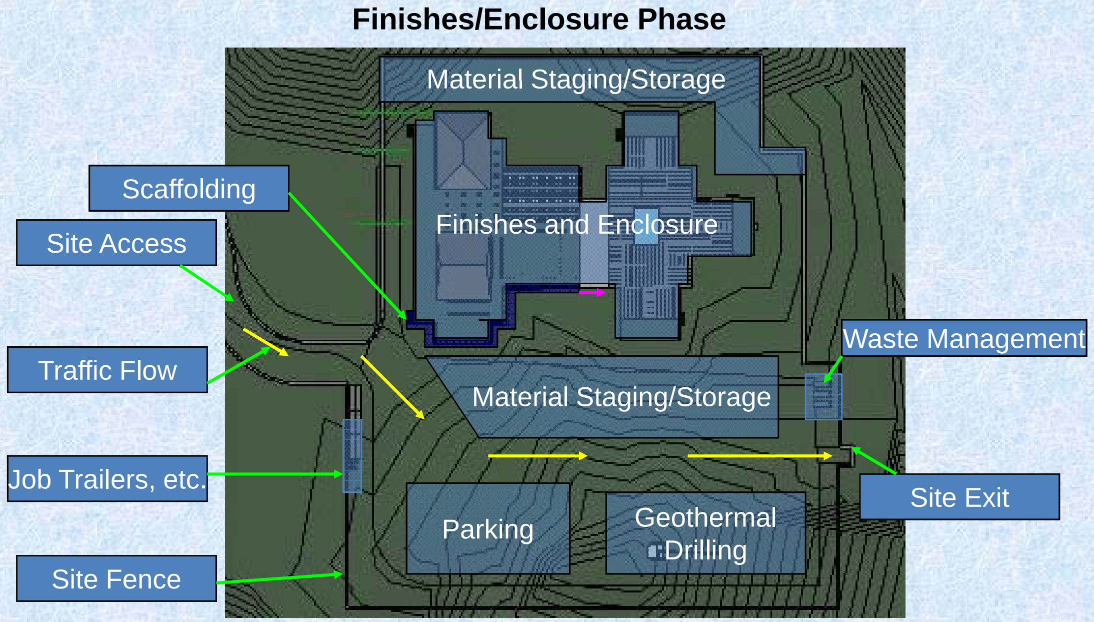
Site Logistics Plan

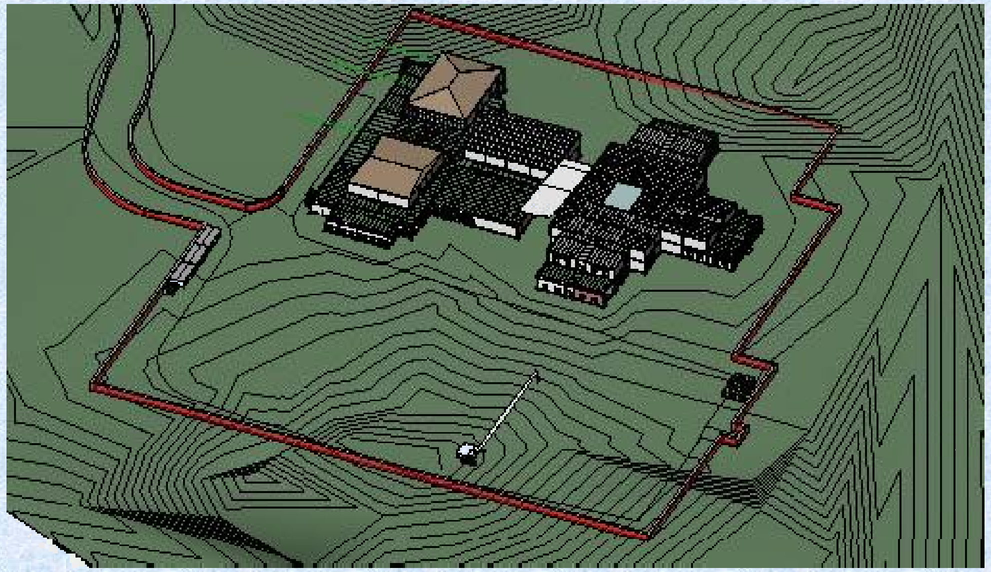
Structural Phase



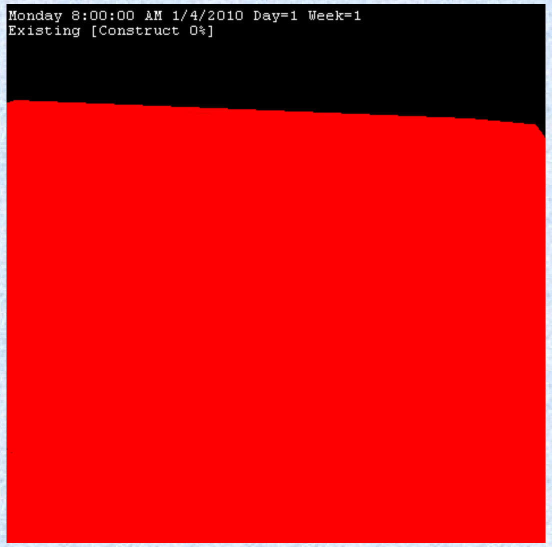


Site Logistics Plan



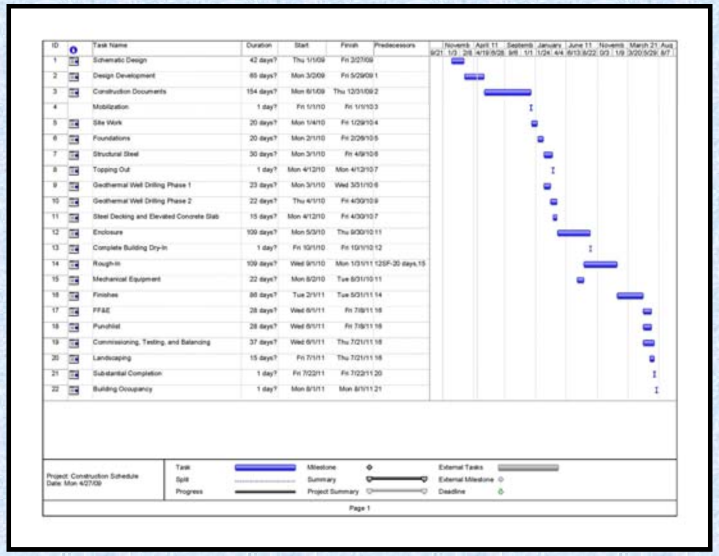


4-D Model



Schedule Risks

- •Utility Tie-In
- •Structural Steel
- •Curtain Wall
- •Green Roof Installation



ID	Task Name	Duration	Start	Finish	Predecessors
1	Schematic Design	42 days?	Thu 1/1/09	Fri 2/27/09	
2	Design Development	65 days?	Mon 3/2/09	Fri 5/29/09	1
3	Construction Documents	154 days?	Mon 6/1/09	Thu 12/31/09	2
4	Mobilization	1 day?	Fri 1/1/10	Fri 1/1/10	3
5	Site Work	20 days?	Mon 1/4/10	Fri 1/29/10	4
6	Foundations	20 days?	Mon 2/1/10	Fri 2/26/10	5
7	Structural Steel	30 days?	Mon 3/1/10	Fri 4/9/10	6
8	Topping Out	1 day?	Mon 4/12/10	Mon 4/12/10	7
9	Geothermal Well Drilling Phase 1	23 days?	Mon 3/1/10	Wed 3/31/10	6
10	Geothermal Well Drilling Phase 2	22 days?	Thu 4/1/10	Fri 4/30/10	9
11	Steel Decking and Elevated Concrete Slab	15 days?	Mon 4/12/10	Fri 4/30/10	7
12	Enclosure	109 days?	Mon 5/3/10	Thu 9/30/10	11
13	Complete Building Dry-In	1 day?	Fri 10/1/10	Fri 10/1/10	12
14	Rough-In	109 days?	Wed 9/1/10	Mon 1/31/11	12SF-20 days,15
15	Mechanical Equipment	22 days?	Mon 8/2/10	Tue 8/31/10	11
16	Finishes	86 days?	Tue 2/1/11	Tue 5/31/11	14
17	FF&E	28 days?	Wed 6/1/11	Fri 7/8/11	16
18	Punchlist	28 days?	Wed 6/1/11	Fri 7/8/11	16
19	Commissioning, Testing, and Balancing	37 days?	Wed 6/1/11	Thu 7/21/11	16
20	Landscaping	15 days?	Fri 7/1/11	Thu 7/21/11	16
21	Substantial Completion	1 day?	Fri 7/22/11	Fri 7/22/11	20
22	Building Occupancy	1 day?	Mon 8/1/11	Mon 8/1/11	21

IPD Evaluation

Our Definition of IPD

Integrated Project Delivery allows for a great deal of input at an early stage of the design.

The investment of time early in the project pays dividends down the road.

Struggles

1. Longer to finalize initial design
2. At the beginning, it is difficult to involve all disciplines
3. Teamwork is always a challenge

Successes

1. More information for architect before design is completed
2. Checks and balances
3. Minimal changes as the design process went along
4. Design for engineers was easier
5. Immediate feedback on design decisions/ideas

BIM Evaluation

Our Definition of BIM

The physical representation of Integrated Project Delivery.

It gives a visual understanding of a multi-discipline approach to design.

BIM is still a work in progress but we feel that it is the future of the industry.

Struggles

1. Difficult to determine what to model and what not to model
2. Trouble with fitting connections in Revit MEP
3. Could not bring RAM designs back into Revit
4. Limited library for lighting fixtures
5. Size of model gets very big, very quickly
6. Construction phasing required a lot of work for little gain
7. Minor issues with worksets

Successes

1. Able to obtain a worthwhile energy analysis
2. Easy to analyze environment and site in Ecotech using Revit model
3. Equipment and material takeoffs were much quicker
4. Revit schedules were helpful in determining accuracy to design program
5. Exporting to RAM was beneficial for structural design
6. Able to get more work done at the same time

Thank You!

Questions?

IDeA